Entrepreneurs and the Formation of Industrial Clusters

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Abstract: This paper outlines the development of a high-tech industrial cluster through the efforts of entrepreneurs who adapted to both constructive crises and new opportunities, creating the factors and conditions that facilitated their business interests. We examine the initial factors influencing individual decisions to become entrepreneurs and how external factors influence the formation and location of high technology clusters. The perspective taken is that entrepreneurs are a critical element in the formation of clusters and their actions are important in the analysis of clusters as complex adaptive systems.

Keywords: entrepreneurship; clusters; regional context; adaptation; complex systems

An earlier version of this paper was prepared for the conference on *Complexity and Industrial Clusters - Dynamics, Models, National Cases* organized by the Fondazione Montedison under the aegis of the Accademia Nazionale dei Lincei, held in Milan, Italy on June 19 and 20, 2001. We are indebted to the individuals who agreed to interviews and generously shared their time and expertise in identifying salient issues as well as providing and validating information.
I. Introduction

Clusters of innovative technology-based firms have a capacity to transform and revitalize local economies, providing economic competitiveness, wealth creation, and jobs (OECD 1993; DTI 1998; Tether and Storey 1998). Porter (1990) argues that a localized concentration of horizontally and vertically linked firms can create and sustain international competitive advantage. Certainly, the economic successes of well-known examples of industrial clusters such as Silicon Valley and Route 128 have fostered attempts to create new industrial clusters. Despite their potential importance and the public resources devoted to them, we have a limited understanding of how innovative clusters emerge, take hold and transform regional economies. Innovative cluster refer to collections of firms within one specialized industry or technology, concentrated within the same local geographical area. These clusters typically include an infrastructure of related and supporting industries and proximity of a strong science base. Markusen (1996) draws a distinction between places that are sticky and able to hold on to new ideas and translate them into industrial clusters and places that are slippery and not able to benefit in the long term from innovation and investment. This characterization does not address the process by which regions change their status, from slippery to sticky, and develop sustainable industrial clusters. Much of the economic development discourse is informed by attempts to replicate the characteristics associated with a fully functioning regional system; characteristics such as a local research university, venture capital, social networks and support services. However, the role typically ascribed to these factors appears to lag rather than lead cluster formation (Feldman forthcoming). More importantly, this perspective ignores the importance of entrepreneurs as economic change agents, able to create or attract the necessary resources and institutions to support their ventures, as well as the rich historical and regional context in which they operate. Models of regional economic development have largely ignored the role of the individual change agent in the development of regional economies (Appold 2000), and have not incorporated the way in which entrepreneurs actively interact with and shape their local environments (Saxenian 1994). In addition, institutions are typically treated as exogenous rather than as evolving, adaptive social constructs.
(Nelson and Winter 1982). Moreover, despite political interest in the supply of entrepreneurship, economists have had relatively little to say about the role of the entrepreneur in the formation of small enterprises that develop into large corporations (Blanchflower and Oswald 1998).

Entrepreneurs appear to be a critical element in the formation and the vibrancy of clusters of technology-intensive firms. Schumpeter (1942:132) described entrepreneurs, not as passive forces in the economy, but as active agents that seek to organize resources and actively refine the environment to be conducive to their pursuits. Entrepreneurship is a local event; individuals start companies in the location where they have formed business networks and have access to resources. The second section of this paper provides a descriptive model that places entrepreneurs at the center of cluster formation as agents who re-define, combine and deploy resources to create new products, services, and organizations. Through the process of creating new companies, entrepreneurs spark regional industrial transformation, a transformation that exhibits path dependence, adaptivity, and self-organization. Entrepreneurs, in the process of furthering their individual interests, may act collectively to shape their local environments by building institutions that further their industry needs. This conceptualization draws on the literature on complex systems, emphasizing that systems of innovation are not predictable linear processes but instead relies on adaptive, self-organizing behavior. In their decisions to start companies, entrepreneurs as the agents of change, draw on resources in the local environment. Their success subsequently shapes the local environment as they reinvest their profits, extend relationships, and build institutions. Over time, a successful cluster becomes entrenched, as the success of the early entrepreneurs attracts resources such as venture capital and specialized labor to the region and as institutions and government enact policies to promote the cluster. This induces others to entrepreneurship and deepens the cluster.

The example of the U.S. Capitol region, examined in section three, illustrates the model2. By any number of measures, this region lacked attributes associated with an entrepreneurial environment (Feldman forthcoming). Yet, technological clusters based on entrepreneurial activity in biotechnology and the Internet have established in the Capitol region3. By considering the early entrepreneurial efforts through which these two industries seeded and established themselves in the region, the approach taken is appreciative history-friendly theorizing (Malerba et al. 1999; Teubal and
Andersen 2000). For external validity, we compare and contrast our findings with the genesis of Silicon Valley (Leslie and Kargon 1996; Saxenian 1994). The intention is to provide prescriptive information that does not rely on trying to replicate the conditions of existing clusters for those regions attempting to promote entrepreneurship and economic restructuring. The final section of this paper emphasizes the uniqueness of each region and the ability of creative individuals to capitalize on that unique environment.

II. Model of Entrepreneurs and Cluster Formation

We know a great deal about the characteristics and functioning of mature industrial clusters such as Silicon Valley, CA and Route 128 near Boston (see, for example, Saxenian 1994; Roberts 1991). Critically important from a policy perspective is the question of how a cluster is started in a region that previously would not be characterized as innovative. We have a limited understanding of how such clusters develop and why they occur in certain areas and not others. For example, looking at the electronics industry, Leslie and Kargon (1994) wonder, “Why should the electronics industry evolve so differently in one place than in another, despite common technologies and national markets? Why, for instance, should Silicon Valley be located in northern California rather than in northern New Jersey?” We develop the argument that the location of entrepreneurs with the skills and opportunity to capitalize on an emerging technology significantly affect high technology clusters emerge. The decision to start a firm is complex and it can be viewed from a variety of perspectives (Bhide 1999 provides a review). Neoclassical economics has focused on entrepreneurs as individuals with lower than average risk tolerance and assume that risk aversion and the uncertainty of potential gains limit the supply of entrepreneurs (see, for example, Holtz-Eakin, Penrod, and Rosen 1996).

Interestingly, although entrepreneurial households report higher risk tolerance than non-entrepreneurs in surveys⁴, there is uncertainty as to whether causality runs between risk-taking and subsequent success or if successful entrepreneurship, (i.e., wealth creation), leads to lower risk aversion (Carroll forthcoming; Blanchflower and Oswald 1998).

Classical work on entrepreneurial activity, such as Schumpeter (1939), Knight (1921) and Kirzner (1973) by contrast, suggests that entrepreneurs have a greater ability to perceive opportunity,
accept challenges and organize resources. Blanchflower, Oswald and Stutzer (2001), drawing on this tradition, theorize that the differential ability of perceiving opportunities and subsequently acting upon them as well as capital market imperfections are the most significant factors affecting the decision to become an entrepreneur. In this paper we build on this tradition assuming that the entrepreneurial decision is a complex mix of individual preferences, opportunities, and access to capital markets.

Schumpeter (1942:131-132) argues that “…the function of entrepreneurs is to reform or revolutionize the pattern of production by exploiting an invention or, more generally, an untried technological possibility for producing a new commodity or producing an old one in a new way, by opening up a new source of supply of materials or a new outlet for products, by reorganizing an industry and so on. … To undertake such new things is difficult and constitutes a distinct economic function, first, because they lie outside of the routine tasks which everybody understands and secondly, because the environment resists in many ways that vary, according to social conditions, from simple refusal either to finance or to buy a new thing…” Thus, the entrepreneurial decision is predicated on both the break with routine and the incentives that lower the cost and risks of start-up ventures. When an environment provides a mix of resources and opportunity, entrepreneurial individuals will move to capitalize on the opportunities by organizing resources. Schumpeter (1934; 1942) placed entrepreneurship, with a connection to dynamic uncertainty, at the center of economic reasoning by tracing all disrupting economic change to innovations and identifying the entrepreneur as the innovator (Blaug 1985). The origin of the entrepreneur as the pivotal actor in an economic system, however, dates at least to Cantillon, an 18th century businessman, and the Physiocrats (see Hébert and Link 1988 for a discussion).

Just as Schmookler’s (1966) scissors metaphor posits that innovation is simultaneously the product of supply and demand, entrepreneurship may similarly require the convergence of opportunities with constructive crises as industrial patterns change. A convergence that generates a reduction in the risk of start-up ventures in a new field, as well as introduces new opportunities and resources that positively affect the probability of success. The entrepreneurial decision is correlated with the receipt of an inheritance or some economic windfall (Carroll forthcoming) and as well further motivated by a decrease in job market security or career advancement.
Entrepreneurship is inherently a local phenomenon. Individuals start companies based on their prior experience and interests, typically fulfilling some niche that a larger corporation may judge too small, exploiting a new opportunity that may have a risk profile unsuited to a larger corporation, or using a unique set of skills and knowledge to develop applications from licensed patents. In building their company, entrepreneurs rely on their local contacts, connections, and knowledge of the business environment. Many individuals have location inertia due to reasons such as family mobility constraints, locational preferences, familiarity of the environment, the relatively higher costs associated with changing residence, or the high cost of establishing a new company in a thickly populated environment where office and housing costs tend to be higher. As one interviewee rhetorically asked, “If you are changing your job, would you also want to complicate your life by changing your residence?”

We begin with the premise that any geographic region has latent entrepreneurship, that is, individuals who prefer to be self-employed or individuals who desire to become entrepreneurs but do not act (Blanchflower, Oswald and Stutzer 2001). The policy question is how to translate latent entrepreneurship into active entrepreneurs. Schumpeter (1942:82-83), in his emphasis on the evolutionary nature of capitalism, proposes that a shock to the system of production is required and that it is this crisis or opportunity that individuals respond to, thus taking the risk to bring innovation to the market. Bygrave and Hofer (1991:19) suggest, “The essence of the entrepreneurial process is a fundamental discontinuity in the industry involved.” In the regional context, the discontinuity may lie in exogenous factors such as corporate policies that promote downsizing or layoffs. In fact, although by the early 20th century, a great diversity of theories of entrepreneurship had been proposed, they all shared the common viewpoint that “entrepreneurial activity is a response to some exogenous force exerted on the market system.” (Hébert and Link 1988:99). It was Schumpeter who declared the entrepreneur to be an endogenous factor, rather than an actor responding to exogenous market forces. Although these theories ascribe very different roles for the entrepreneur within an economic system, below we develop an explanation of how entrepreneurship can be a response to exogenous market factors and yet the entrepreneur is shaped by and shapes his environment, becoming an active and integral component of his environment. Further, combining Schumpeter’s dynamic role for the
entrepreneur, with Knight’s interpretation of the entrepreneur as the bearer of risk, we can more fully understand how entrepreneurship took hold in the Capitol region.

If the entrepreneurial decision is sufficiently sensitive to exogenous factors, rather than being merely a function of preferences, then it can be influenced both positively and negatively by government policy. The model posits some initial change, whether a crisis, a discontinuity in industry or an opportunity, creates the impetuous for latent entrepreneurs to engage in starting companies. This sets into motion a series of responses in the institutional, environmental and policy environments that influence the success of a region in maintaining these start-ups and furthering the maturation of the cluster and create the “stickiness” of the region in Markusen’s (1996) typology. The ability of a region to adapt to exogenous shock may depend on the alignment of incentives and environmental resources that promote the transfer from latent to active entrepreneurship. The local environment, in terms of the types and quality of resources, the networks and institutions that provide support and further business interests, ultimately affect the sustainability of the start-ups. In sum, an industrial cluster is an agglomeration of mutually reinforcing firms and aligned interests.

Figure 1: Factors in the Formation of the Region

![Diagram showing the interdependent nature of factors in the formation of a region.](image)

Adapted from Burton et al. (2003).

Figure 1 presents a schematic incorporating these ideas and depicting the interdependent nature of the relationships among entrepreneurship, government policy and environmental resources and geographic factors. In the diagram, both the local environment, which includes social and business institutions and physical and human capital resources, and government policy influence entrepreneurial decisions. In a well-functioning entrepreneurial system, each component positively
reinforces the other, promoting industry development and the evolution of a cluster. Once the incentives and the environment are aligned, the result is a fully functioning industrial cluster that is able to sustain economic growth as well as withstand adverse shocks. The Figure not only depicts the relationships in a well-functioning entrepreneurial environment, but also the multi-faceted nature of the decision to start-up a company. Although the relationships among the components evolve from emergence to stability and maturation of the cluster, the essential interconnectedness remains constant.

This model is in contrast to the typical story describing the evolution of Silicon Valley, Route 128 or Research Triangle Park. For example, Kargon, Leslie and Schoenberger (1992), emphasize the early input of Frederick Terman as the founder of Silicon Valley who orchestrated the creation of a world-class research institute with strong ties to the business community and an environment that encouraged students to become entrepreneurs or at least to take active involvement in corporate research programs. Research Triangle Park was also built on dedicated public sector efforts (Link 1995) while Route 128 was built on a long tradition of university-industry interaction and leveraging of government contract work (Kenney and von Burg 1999). These well-known examples of the U.S. high-technology sector may be prominent examples, and their development may represent one model of cluster development that is not easily adaptable to other regions. In contrast, we posit that the typical formation of an entrepreneurial environment is more organic and cumulative. A cluster’s characteristics, from the genesis to maturation, are shaped and influenced by local factors.

Figure 2 demonstrates the evolution of a high-technology industrial cluster over time as a series of three phases. In the earliest stages, there is little technology-intensive industrial activity. Although, a region may have the type of human capital or prominent research universities that might be associated with an industrial clusters, few start-up companies would exist. The movement from latent to active entrepreneurship requires some shock possibly to the demand for entrepreneurs or traditional business, whether private or public sector, as well as a reduction in the opportunity cost of entrepreneurship. Once the initial entrepreneurial ventures have been sparked, the process of entrepreneurship is a classic trial and error or learning-by-doing process (Zaltman, Duncan and Holbeck 1973). In this sense, the learning process and the adaptation to new events and to the
existing environment are important determinants in the development of the cluster. The evolution of the new firms depends itself on the start-up process, the regional (and national/international where relevant) demand as well as the available resources in the region. The cluster and the characteristics of the cluster therefore emerge over time from the individual activities of the entrepreneurs and the organizations and institutions that co-evolve to support them.

The second phase is dominated by increased entrepreneurial activity as an adaptation to a series of changes in the external environment. In the case of the Capitol region, these efforts were a response to creative crisis due to federal downsizing as well as to new opportunities precipitated by changes in the legal framework – the local effect of changes in the national policy environment. During this stage, entrepreneurs defined resources to promote and protect their interests. In this way, the independent actions of entrepreneurs are catalytic components of a self-organizing system. Further, the cluster self-organizes around the entrepreneurial activities. Entrepreneurial activity is
creative and innovative and therefore, the specific needs of the entrepreneur cannot be predicted *a priori*, but develop over time as start-ups are created and the needs are recognized. Once a critical mass of start-ups is in place, supporting organizations are attracted. The organization of the cluster and the entrepreneurial ventures evolve simultaneously and even symbiotically. Having the experience and example of the initial start-ups, the industry becomes self-sustaining: entrepreneurs attracted physical and human capital to the area, public and private networks built up to support and facilitate the ventures, relevant infrastructure was created through public and private initiatives and services grew up to feed these companies. For some regions, exogenous shock, such as corporate mergers and acquisitions may compact the industrial sector into a small number of large multinational firms or a more research oriented cluster, such as the case of the New Jersey electronics industry rather than promoting new firm formation.

Maskell and Malmberg (1999) propose that technology clusters may be conceived as ecologies of mutually dependent firm and institutions. The entrepreneur then, operates in and stimulates his local environment to further innovation and localized learning. It is in the creative feedback response of the entrepreneur to his environment that determines the nature and stability of the cluster. Looking at clusters such as Silicon Valley, the Texas conurbation, Research Triangle Park, and the Capitol region, we see that entrepreneurship responded to each unique environment, creating clusters each with their own signature characteristics as well as different abilities to withstand external shocks (Leslie and Kargon 1994; Saxenian 1994; Link 1995; Engelking 1999; Feldman forthcoming).

The ultimate result is a fully functioning entrepreneurial environment within an innovative and adaptable industrial cluster. The success of the initial start-ups, and the synergy between them, generates new possibilities for further start-ups and new spin-offs. Networks of entrepreneurs, policy makers, and secondary industry contractors spring up; universities, colleges and technical centers recognize the need for high-tech trained personnel and offer programs to satisfy that demand. The success and experience of the initial activity further generates local recognition of the nascent industry. Local recognition, a reduction in risk, and more opportunities created by the initial companies, contribute to more start-up activities. The third level further shows the linkages between
the emergent phase and the maturing phase. The final stage is the establishment of a critical mass of resources, some developed within the region and other resources, such as venture capital, locating in the area. It is also at this stage that we see the creation of regional public sector financing and grant giving programs. The critical mass of start-up activity has spawned the necessary infrastructure to sustain it, which has in turn attracted more activity to the region. We see that once a minimum efficient level of activity is in place, venture capital is attracted from other parts of the nation and the industry begins to mature. Government policy creates further incentives for investment, incubators and other technology partnerships are created to promote growth of the industry and mergers and acquisitions begin to thin out the companies. Successful entrepreneurs also move from their initial start-up to start other companies. In the figure, we see that the performance and positive outcomes of the initial set of start-ups feeds back into the system, generating opportunities for more start-ups. The maturing industry spurs policy changes as government seeks to attract and provide a flourishing environment for even more high-tech development.

One striking fact that emerges is that the history of each cluster is unique, suggesting that the dynamic of cluster development is path dependent or heavily influenced by history (Kenney and von Burg, 1999). In Silicon Valley, for example, we see the strength of the aeronautical and electronics industries championed into a high-technology conurbation by a small group of people with a vision for the development of the region. While in the Capitol region, changes in government structure and science and innovation policy sparked a frenzy of activity that drew resources to itself as it grew. The next section offers an interpretative history of the emergence of high technology clusters in biotechnology and ICT in the U.S. Capitol Region as an illustrative example.

III. Entrepreneurship Comes to Washington: An Interpretive History

The region around the U.S. Capitol recently emerged as a hotbed of entrepreneurial activity, wealth creation and economic growth. This reflects a transformation of the region from an economy dominated by public sector employment and not considered innovative or supportive of private sector activity (Feldman forthcoming). In an attempt to understand this transformation, we have studied the genesis of entrepreneurial efforts. Our analysis is an interpretive summary based on interviews with
entrepreneurs in biotechnology and ICT. The interviews gathered information on: where entrepreneurs were employed prior to starting their companies, what the motivation was for starting their companies, what resources they used in developing their companies and the technologies and the subsequent spin-off activity they generated.

The Capitol region has the third largest concentration of biotech companies in the United States (Price Waterhouse Coopers, 1998). Leading companies in the region include Human Genome Sciences (HGS) and Celera Genomics Corporation, two key actors in the international effort to map the human genome. In addition, another local company, MedImmune, is the world’s eighth largest dedicated biotech company with six FDA approved products on the market.

The ICT industry also has a strong presence in the Capitol Region with a concentration in Northern Virginia. According to some sources, the region may be regarded as the birthplace of the Internet. Prominent companies in the region include MCI, AOL, NexTel, and PSINet. Companies in the region supply half of the worldwide Internet backbone (Price Waterhouse Coopers 1998).

Biotech and ICT are different industries; they share only in the fact that they are fast growing, knowledge-intensive sectors. Nevertheless, there are some notable patterns in the origins of the companies in the region and their development over time. First, despite the importance of the federal government as an employer, entrepreneurs hail from a variety of different prior organizations. The earliest entrepreneurs were drawn from large corporations, government suppliers or military retirement. Government institutions, which are prominent in fields related to ICT and biotech, did not generate many start-ups until government policy changed, instituting employment downsizing and policies to promote technology transfer. The new start-up firms created soon after the policy changes, became particularly fruitful in generating second, third and fourth generation start-ups. Second, the earliest start-ups were service firms, not originally involved in the types of R&D-intensive activities that generate new industries. Firms such as Bethesda Research Labs and American Management Systems (AMS) were not launched as product development firms although they evolved in that direction over time. Thus, the cluster had rather humble beginnings – service firms do not typically attract attention from venture capital or local economic development officials. But these firms were relatively less costly to start and provided a means for entrepreneurs to get started. Finally, and most
importantly, entrepreneurship picked up momentum in both industries. Over time, generations of new
firms spun-off from the earliest start-ups and entrepreneurs who cashed in from one new venture
created other companies. Institutions and a culture supportive to entrepreneurship developed and the
barriers to creating a company decreased.

Two basic features in this interpretive history stand out: although the Capitol region did not
have the generally regarded prerequisites for high technology development, a confluence of unrelated
events created an opportunity for entrepreneurial individuals to create start-ups. Second is that the
organizations and entrepreneurial ventures co-evolved. Both the biotech and ICT industries had
humble beginnings in the region and initially there was a low level of activity. However, as
entrepreneurship caught hold, the industry as we observe it today began to emerge and the necessary
components to sustain it grew up in the region.

The narrative continues by considering the development of the cluster into three phases
following Figure 2. The first phase, the emergent phase, occurs when entrepreneurial innovation is
ignited by a confluence of exogenous events. The self-organization of the cluster and the deepening
of the self-reinforcing feedbacks among entrepreneurs, enterprises, institutions and resources
characterize the second phase. The third phase is the maturation of the industry into the well
functioning and rich innovative and entrepreneurial system we observe currently. Each of these
phases is examined in turn.

IV. Emergence of a Cluster

Lacking the strong cooperative environment and culture of university-industry technology
transfer that characterizes the history of Silicon Valley, the Capitol region developed as a creative
response to outside factors. In this section, we discuss these factors and how they coalesce to form a
complex adaptive system of innovation.

There were some positive pre-existing conditions in the region such as a long tradition of
federally funded science. The National Institutes of Health (NIH), the U.S. agency whose mandate is
to oversee health and medical research, is a defining characteristic of the Capitol region. It employs a
large number of researchers at the agencies’ home campus in Bethesda, Maryland. Other government
institutes and agencies, such as the Walter Reed Army Institute for Research (WRAIR) and the U.S. Food and Drug Administration (FDA) also have expertise related to the biotech industry. The modern computer networking technologies that are the backbone of the Internet and ICT emerged in the early 1970s from the U.S. Department of Defense Advanced Research Projects Agency (variously called ARPA and DARPA) (see Kahn and Cerf 1999 for more detail). Nevertheless, in order to activate those resources, a set of events was needed to change incentives for entrepreneurial activity and create an opportunity for individuals who were enterprising and adaptive.

Between 1970 and 1990, the Capitol region was affected by a series of exogenous policy shifts that, while intended to have national consequences, had dramatic ramifications for the region. Beginning during the Carter administration in the 1970s, there was a pronounced downsizing in federal employment that continued through the Reagan presidency. As a result, federal employment became less secure, compensation levels were frozen and future prospects deteriorated. Many affected individuals had strong personal ties to the region and suffered from what may be described as locational inertia. However, simultaneously an opportunity for entrepreneurship emerged. The Civil Service Reform Act of 1978 contained an initiative to outsource the production of goods and services to the private sector creating new opportunities. Thus, individuals in the prime of their careers found entrepreneurship a viable employment option. Government downsizing and outsourcing had in effect lowered the threshold for entrepreneurial risk-taking. Federal procurement spending in the Capitol region grew by 114.3 percent from 1983 to 1997 while federal procurement spending increased by 3.1 percent during this same period (Haynes, Fuller and Qiangsheng 1997: 149). The Reagan administration defense initiative in the 1980s was materially different from other defense initiatives as it focused on the technical and software attributes of defense9. While this initiative stimulated economic growth throughout the United States, the National Capitol Region was one of the major beneficiaries (Stough, Campbell and Haynes 1998)10.

In 1980, as a response to declining American competitiveness, a new era in the transfer of publicly funded intellectual property to industrial firms began with the passage of the Stevenson-Wydler Technology Innovation Act and the Bayh-Dole University and Small Business Patent Act. The large number of federal and university labs in the Capitol Region were allowed to license their
innovations to private firms. In addition, the Small Business Innovation Development Act of 1982 established the Small Business Innovation Research (SBIR) Program. Under this Act, all federal agencies with an annual R&D budget greater than $100 million are required to set aside a percentage of R&D funds for small business. The Act thus greatly increased the funding available to technologically oriented small business (Lerner 1996).

In conclusion, entrepreneurship in the region was a response to exogenous factors: underemployed skilled labor brought about by changes in federal employment policy coupled with new opportunities for the private sector to contract with the federal government and commercialize new technologies. The two industries considered here responded to different pressures. The advent of entrepreneurship was reactive and adaptive. While both sectors benefited from the great opportunity for commercial products from licensing federally funded innovations, biotechnology was more influenced by CRADAs and opportunities for licensing and joint product development while ICT benefited more from outsourcing opportunities. In both cases, locational inertia kept the entrepreneurs in the area. Over time, the region has developed the supporting conditions the literature associates with entrepreneurial environments. The next section considers how these factors developed.

V. Self-Organization Follows

In the startup phase, entrepreneurs began by pursuing commercial projects that did not require high levels of investment and which were unlikely to generate the type of large profits that would interest venture capitalists. They started with government contracting, producing rather mundane bread and butter products, such as medical test kits and reagents for biotechnology or services such as computer system integrations and maintenance work in ICT. Most companies appear to have started with personal funds rather than venture capital, a finding consistent with the literature (Bhide 1999; Blanchflower, Oswald, and Stutzer, 2001). In addition, the growing number of related firms in the region provided opportunities for subcontracting, work and asset sharing, thus making it easier for the start-up firms to bootstrap and steadily grow without large doses of new capital.
Venture capital seeks opportunity and when there are potentially profitable investment opportunities in a region, venture capital is attracted. Being able to monitor and mentor the entrepreneurial firms in which they invest makes close geographic proximity valuable for venture capitalists (Gompers and Lerner 1999). In 2000, there were six venture capital firms headquartered in the region and firms located elsewhere have opened Capitol region branches.

Over time, as the earliest start-up companies grew and went public, or were bought out by other companies, the dynamics of the region changed. Most notably, local entrepreneurs who made large fortunes engaged in institution building to support their activities and to encourage further entrepreneurship. Also important was the emergence of networks of supportive social capital that began as membership organizations to promote networking. These activities were primarily private sector initiatives, financed with private funds. By collaborating with state and local government programs, these initiatives resulted in cross-fertilization and a common mission to promote the development of industry in the Capitol region.

There are several cases where early entrepreneurs, who had made personal fortunes, started private incubators to nurture other new companies. These founders were motivated to share their expertise and to build the region. In addition, at least three angel networks have formed in the last five years. The Private Investors Network (PIN), the Capital Investors Club and the Washington Dinner Club are organizations of experienced entrepreneurs who actively invest in new companies and offer management advice.

Older style quasi-public organizations such as the Washington Board of Trade and the Greater Baltimore Committee have broadened their agendas and spun-off new organizations directed at technology intensive industry. Other government-financed programs found greater success by collaborating with the privately organized networks (Guidera 1996). Universities in the region have responded to the increased entrepreneurial activity by offering new programs and building branch operations closer to commercial activity. For example, Johns Hopkins University offers a Masters degree in Biotechnology in Silver Spring, Maryland about 50 miles away from the main Baltimore campus, but within a few miles of a major concentration of bio-tech firms. Virginia Tech University opened a branch campus in Northern Virginia about 250 miles from their main campus, though again
within the ICT cluster. The draw has been the number of workers seeking additional training, the opportunities for industry-funded research and the interaction with industry. Notably, the local universities have benefited from the philanthropy of local entrepreneurs. For example, George Mason University began in Fairfax, Virginia in 1950 as a commuter school. It has grown into Virginia's second-largest university with 18 doctorate programs and a focus on technology. Donors have given the university millions of dollars to endow 43 professor chairs, allowing the university to recruit high-profile professors (O’Harrow and Lipton 1996). All of the universities in the area have responded with incubators and other programs to encourage entrepreneurship.

In the Capitol region, legislative programs also followed the initial phase and addressed the needs of the newly established industry. For example, a group of Virginia business executives organized a broad campaign to advocate state tax increases for education in order to address a noted shortage of technology workers and provide greater infrastructure funds (Baker 1995). This initiative attempted to build infrastructure to support the development of local industry. Rather than seeking specific requests for their own business, business leaders were promoting a broader, collectively responsible social agenda (Feldmann 1997). In 2001, the state of Maryland passed twelve legislative acts focusing on providing a supportive environment for technology-based economic development. These cover the full gamut of infrastructure development, training programs and tax incentives.

VI. Critical Mass and System Maturation

The development of high technology clusters is not a deterministic process. Some clusters have developed into research centers in their mature phase while others have slowly deteriorated from what appeared to be an initially vibrant maturing phase (Leslie and Kargon, 1994). However, there are several factors associated with cluster maturation and stability: strong industry networks, supportive local culture and the ability to withstand re-configuration (Andersen and Teubal 1999) or adverse shocks (Saxenian 1998). There is evidence that the Capitol high tech clusters in ICT and biotech have achieved a point where they are self-sustaining. The factors that typically describe industrial clusters such as strong industry networks and a supportive local culture are in place. While
there is no quantitative measure of when a mature cluster exists, there are two important characteristics. The first relates to the thickness of the labor market. A mature industrial cluster offers myriad job opportunities in an industry making it possible for an employee to change jobs without changing residence. Anecdotal evidence indicates that this is the case in the Capitol region for both ICT and biotech. Another characteristic of mature clusters is the ability to adapt to adverse shocks such as economic downturns (Saxenian 1994). Although brilliantly successful clusters highlight the history of high technology in the U.S., it is also marked with cluster failures—clusters that were not able to adapt to shocks and whose entrepreneurs and start-up activity folded or went elsewhere when the environment became negative (Leslie and Kargon 1994). The ability to reconfigure resources in response to change is an important indicator of maturity (Andersen and Teubal 1999). The Capitol region appears to have weathered the recent national decline in stock prices and while there was some industry consolidation, both the biotech industry and ICT appears to be firmly entrenched, as evidenced by the continued growth in numbers of start-ups, government sponsored programs and incubator facilities, among others.

In sum, these factors when added together represent a whole that is larger than its parts and a system which is self-sustaining and reinforcing. The mature state of the Capitol region looks not much different from Silicon Valley, in terms of venture capital, major research university involvement, university-technology transfer practices, and the types of social capital and entrepreneurial efforts observed. Nevertheless, the genesis of each region is much different--two rich self-sustaining high-technology clusters which appear similar on the outside, but evolved through entirely different paths.

VII. Reflective Conclusions

The economic success of Silicon Valley in terms of individual wealth creation, corporate profits and job creation, has been so impressive it has pushed government officials in locations across the nation to try to imitate or replicate its success. Government policies aimed at replicating the conditions that exist in the region today are based on the belief that their local areas may also capture the benefits of new high technology firm formation and the attendant economic growth. Much of the
prevailing conventional wisdom is drawn from a snapshot of the advanced stage of Silicon Valley’s
development, that is, on the workings of a fully functioning innovative system. Looking at a
successful region in its full maturity, however, may not provide prescriptive information about how
such regions do develop. Conditions that we associate with an entrepreneurial environment are the
result of a functioning entrepreneurship and do not illuminate the early efforts by which such
entrepreneurship first took hold and the cluster developed.

A critical question is how regions change and develop into areas with higher growth potential.
Is replication of a mature entrepreneurial environment sufficient to foster entrepreneurship? Notable
failures in such places as Dallas and Boston route 128 (Leslie and Kargon 1994) suggest it is not.
Saxenian (1994) analyzes Silicon Valley from the perspective of how it adapted to restructuring in the
semiconductor and computer industry and establishes the importance of social relationships in
defining the capacity of the region to evolve, adapt to shocks and accommodate new demands. In this
paper, we have examined how one region, initially lacking an entrepreneurial tradition, accomplished
the transformation to a fully functioning rich regional system. Such a transformation entails a
fundamental shift or phase change from an inert innovative system to an active system. Certainly, the
Capitol Region was the site of large government research infrastructure, classified as a State-anchored
region using Markusen’s (1996) typology. In this regard, the concentrations of resources and highly
skilled labor plus access to sophisticated, demanding technology users were pre-existing conditions in
the region. The transformation to private sector entrepreneurial growth did not appear to represent
movement along a technological trajectory (Kenney and von Burg 1999) but instead was a sustained
effort at capacity building that involved human agency, adaptation and evolution. Not only this, a
critical point was reached in the development of the region when it jumped from virtually no high
technology start-up activity to intense activity with start-ups per year numbering in the hundreds.

In the development of an industrial system of innovation, there are many individual complex
stories and personal motivations. It has been said that government employees and contractors could
never become successful private businesses – the incentives were very different. Government
workers, the logic went, were too removed from the pressures of the market. Government contracts
followed a practice of placing a low bid in order to get the job and then making a profit by
demonstrating a need for change orders in the absence of competition. This is a very different philosophy from trying to do a job right the first time at the lowest cost. However, the earliest entrepreneurs in biotechnology and ICT were government contractors and employees who proved this logic wrong. What is critical is that the region did provide opportunity for individuals. They began working for the government but then realized that they could adapt their products for dual-use commercial markets. Therefore, they moved to commercial markets and with this development came the earliest start-ups. Eventually they succeeded. In essence, this was a phase change from latent to active entrepreneurship.

The entrepreneurial event in the Capitol Region was a response to and adaptation to changes that were exogenous to the regional system. In this regard, Federal policies such as downsizing created slack and surplus resources that could find new and more productive uses. Thus, the gales of Schumpeter’s creative destruction were unleashed. Policies that created a supply of potential entrepreneurs would not have been sufficient. A complementary set of government policies aimed at creating demand for ICT and biotechnology services through government procurement facilitated the transition. Other exogenous conditions were the policies that provided mechanisms or tools to enable companies to access resources. These affected the supply of new ideas by creating access to intellectual property from government investment.

Both biotechnology and ICT are high opportunity technologies facing growing product demand and therefore are attractive to investors. Firms working in these technologies face favorable market conditions. The degree to which this is exogenous may be debated. Good entrepreneurs may create their own opportunity and thus define the industry. The idea that technology development is endogenous to cluster development warrants more investigation. Through the actions of key individual change agents, the configuration of the cluster and the technological trajectory of the industry may be jointly determined. It does suggest that companies, industries and regions benefit from the same factors and decisions -- their evolution may be intricately interwoven.

Currently, a myriad of economic development policies attempt to encourage entrepreneurship. We have shown that rather than being actively promoted and encouraged by economic development policies, these activities had much more humble and pedestrian beginnings. The conditions that we
associate with entrepreneurship developed over time. In the early stage of these new technologies, the way in which they would develop was unclear and it would have been difficult to anticipate the types of specific assistance that entrepreneurs needed. Individual entrepreneurs were in the best position to move the technology, the industry and the region forward. This is not to say that there is no role for local government policy in promoting entrepreneurship. Although no early examples presented themselves in the Capitol region, we have not directly examined that question. It is interesting to note that the Silicon Valley success is viewed as an outgrowth of the intense technology transfer and interaction between industry and universities in that region. Local government policies did and do play a role, but these tend to be implemented and effective in the later stages of cluster development.

Are there general lessons to be learned from the development of the Capitol region or is this case unique and is every case unique? Certainly, this region benefited from high average household income and higher than average education levels, giving it very different resource endowments from other underdeveloped regions lacking an entrepreneurial culture. The general lesson is that entrepreneurs adapt and when they are successful, they build the types of resources that support their activities.

A distinction should be drawn between the conditions that support innovation and the conditions that support entrepreneurship. The two concepts are related: entrepreneurship facilitates the realization of innovation, as firms are formed to commercialize and advance new ideas. Conducive external environments and resources make innovation activity easier but may not be sufficient to induce new firm formation, which is where the concepts diverge. The critical condition for entrepreneurial enterprise is opportunity. Even if the regional conditions do not match those of successful clusters, the incentive to developing locational opportunities leads entrepreneurs to start firms.

Once established, industrial clusters become virtuous, self-reinforcing cycles. Legal and tax frameworks, research institutions and social relationships are definitely areas for public policy intervention in terms of creating a supportive and positive environment for innovation and entrepreneurship. Specifically relevant are the conditions that affect the decisions of individuals to become entrepreneurs, and the ways in which an entrepreneurial culture develops and takes hold. Yet,
our understanding of regional economic systems may be enhanced by a consideration of entrepreneurs as economic agents who actively interact with their local environments, adapt to new situations, crises or opportunities using location-specific assets, and finally, build and augment local institutions.

Certainly, this is not the last word on this topic. It is my hope that this historically informed appreciative theorizing will inspire others to take a more detailed look. It is only through an appreciation of the nuances of cluster development that we may begin to adequately inform policy.
References


Guidera, M. 1996. “Start-ups finding it easier to get paired with ‘angels’; University of Maryland’s Dingman Center joins Investor Network in matchmaking effort” The Baltimore Sun August 21, page 1C.


Endnotes:

1 There is no consensus definition of an industrial cluster. We follow Baptista and Swann 1999 in our choice of definition.

2 The U.S. Capitol Region is considered here as the Consolidated Metropolitan Statistical Area (CMSA) which includes Washington D.C., Northern Virginia and the Maryland Suburbs including Baltimore City and its environs. Two counties in West Virginia were added in 1990.

3 Within the region, there is evidence of geographic differentiation. Biotechnology is primarily concentrated in the Maryland suburbs in Gaithersburg and along the I-270 Corridor. The Internet companies are concentrated in the Northern Virginia suburbs.

4 For example, in the Survey of Consumer Finances, wealthy households report they are more risk tolerant. For a description of these survey results, please see Carroll forthcoming.

5 In the case of the Capitol region, the Carter administration downsizing policy combined with legal changes that affected both the risk of entrepreneurial ventures and the ability to use promising technologies developed with federal funding and hence the creation of new technology based companies.

6 The intention here is not to develop a fully historical treatment of the entrepreneur but rather to explain the catalytic nature of the entrepreneur in the Capitol region. For an excellent survey of the development of the entrepreneurial role in economics, see Hébert and Link (1988).

7 There are some methodological issues to mention. First, it is important to note that this is a retrospective study. We are limited to identifying firms in existence now or that were at one time prominent enough to leave a record. While we are able to trace these firms back to their founding, we have no knowledge of similar firms that were started but may have failed, been acquired or merged into other firms prior to our study. Such a study would involve access to a source of historical data on firms such as tax or employment records to discern when the firms came into existence and when they ceased to exist. This approach would be limited because the smallest and most typical form of startup, the sole proprietorship, might not be captured. Our approach allows us to consider the roots of successful entrepreneurship and the ways in which entrepreneurial activity took hold, but it cannot address the failure of enterprises that died without leaving a record. Although each of these companies has its own unique and compelling founding story, our objective is to discern trends and patterns.
For example, the Virginia Economic Development Partnership (http://yesvirginia.org/wva-be.html) uses this slogan.

This affected ICT but also biotechnology. Consider the firm Martek, a spin-off from the defense contractor Martin Marietta that was funded by DOD but is developing pharmaceutical products and food additives.

For examples see Feldman (forthcoming).